NCR

REFERENCE MANUAL

PROGRAMMING HANDBOOK

SUPPLEMENT 1

MICR Sorter-Reader
Optical Character Reader
90 Column Card Reader
Unbuffered Printer

●

NCR 315

315

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MICR Sorter-Reader
Optical Character Reader
90-Column Card Reader
Unbuffered Printer

THE NATIONAL CASH REGISTER COMPANY
DAYTON 9, OHIO, U.S.A.

PRINTED IN U. S. A.

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MICR SORTER-READER

MICR SORTER-READER

The NCR Check Sorter is designed to operate either as an independent digital (columnar) sorter, or as a peripheral device with an NCR Electronic Data Processing System. Two models are available, operating at 750 and 1620 documents per minute, respectively.

When connected through its Buffer to the Processor, the Sorter is completely controlled by the Processor program, which starts and stops the Sorter, reads into memory the information stored in the Buffer by each magnetically-encoded document and, after making appropriate computations, tells the Sorter which of 12 sorting pockets is to receive the document just read.

The Sorter contains 12 distribution pockets, designated 0-9, SPECIAL and REJECT.

The documents are encoded in magnetic ink along the bottom edge, with arabic digits in a special font (designated E-13B) specified by the American Bankers Association, readable both by the human eye and by the Sorter. The precise specifications for imprinting are set forth in publications of the ABA.

In addition to the 10 decimal digits, the E-13B font includes 4 other configurations, called Q-codes, used to indicate the boundaries of the fields imprinted on the document, and also to identify those fields. The ABA specifications for location and size of each field, and for the use of Q-codes, are quite precise, and should be thoroughly understood before programming a Commercial Bank application.

For any other application, the number of fields on a document, their sizes and locations, and the use of Q-codes, is entirely at the disposal of the designer of the system.

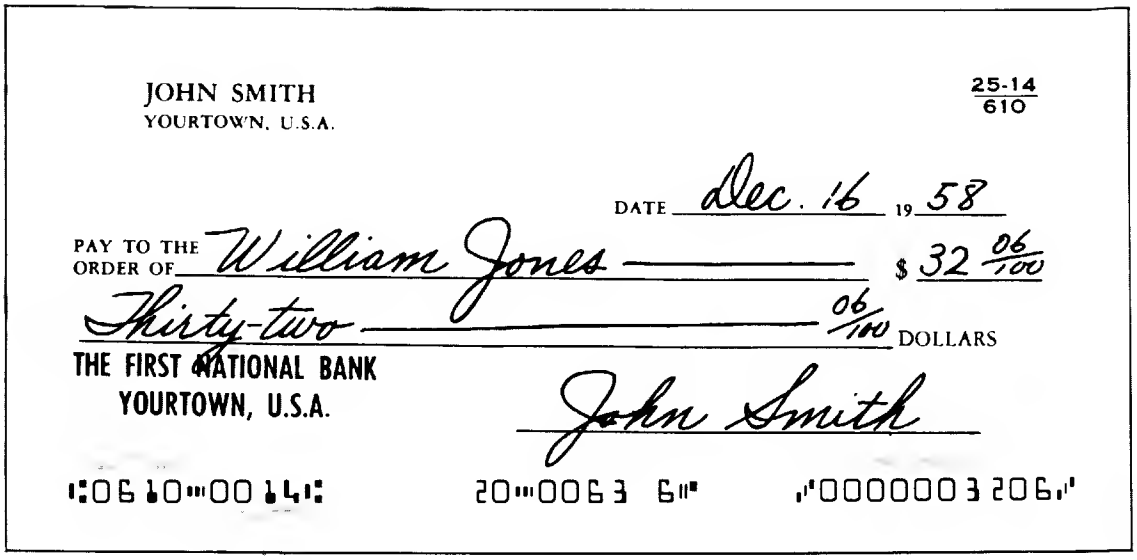
Each of the Q-codes has a unique appearance, and is read into the processor memory as a unique character.

CODE	SYMBOL	READ AS
Q1		•
Q2		&
Q3		,
Q4		@

An MICR-encoded document may contain up to 56 characters (including Q-codes), which are read into the Sorter Buffer, and thence into the processor memory. The Buffer contains 56 characters (28 slabs) of magnetic core storage, which is always cleared to "spaces" before the Sorter reads a check into it. As with all other input and output functions of the NCR 315, the information (even though purely numeric) appears in memory in 6-bit alpha form. The information on the check is stored right-justified in the buffer, so that the left end of the buffer is filled out with spaces. The reading is "self-clocked" so that any variation on the check in the spacing between characters or between fields (within ABA tolerances) will not affect the reading, nor will it introduce spaces between fields.

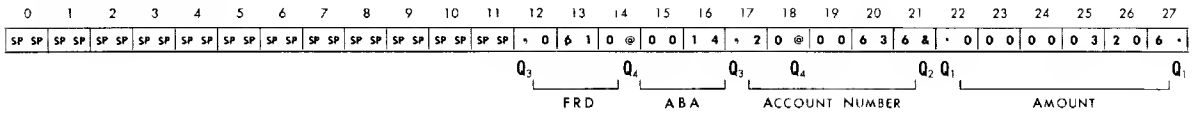
When the Processor addresses a Read Check (RCK) command to the Buffer, these 28 slabs of information are transcribed verbatim into the Processor memory.

As an illustration, suppose the following check to have been read. The date on this illustrative check is that on which the ABA gave final approval to the E-13B magnetic character type-font.



The information from this check would appear in the Buffer, and then in the Processor memory, in the following form:

28 Slabs (56 Characters)



Error Conditions:

The following circumstances are typical of conditions that will cause a reading error:

- A character or Q-code has been improperly printed, and cannot be positively identified by the reading circuits;
- A character is obscured by "noise," such as from iron particles embedded in the paper;
- Some non-MICR information has been printed in magnetic ink within the area reserved for encoded information. In this case, as long as the encoded information has not been obscured, the program can still identify the encoded fields and process the document.

In each of these cases the character *hyphen* is stored in the Buffer for each unreadable character, and when the Buffer is read into the Processor memory there will be a Jump-table exit from the RCK command.

The mere existence of an unreadable character on a document should not necessarily cause the document to be rejected by the program. The information should be scanned to determine if the garbled information is in a critical field. Many checks are printed with non-MICR information, usually the name of the bank, in the area conventionally reserved for the serial-number field at the left end of the encoded line. This will appear as a succession of unreadable characters, and the program should be written in such a manner as to ignore such "errors" if the serial-number field is not required, as is usually the case.

If any document should contain more than 56 characters (including Q-codes) then the right-hand 56 will be stored in the buffer, and the remaining characters will be lost. The Processor program, of course, will detect the fact that the left-hand field is missing or incomplete.

If the Buffer should transmit to the Processor either more or less than exactly 56 characters, both the Processor and the Sorter immediately halt.

Ready Status and Demand Interrupt:

The Processor may accommodate up to 4 Sorter Buffers (each with its own Sorter), and each Buffer has a Unit Demand flag which may be set and cleared by the program.

When a Buffer is READY, and its Unit Demand flag is on, it will transmit a Demand signal to the Processor; if the Processor's Demand Permit flag is on, interrupt will then occur. The READY state, and the Demand signal, will remain on until a RCK command is addressed to that Buffer.

The Buffer becomes READY whenever it has been loaded by reading a check.

If a transport jam should occur, the Sorter forces the Buffer into the READY state, so that interrupt can occur. The RCK command will take an appropriate jump to indicate that there is a jam, and then the Buffer is no longer READY. A jam will cause interrupt only until a RCK command takes the jump; thereafter, SELS commands will find that Buffer not READY.

Selection of Units:

As with other multiple peripheral units, the commands which address the Sorter Buffers do not specify which unit is addressed; it is necessary to *Select* the desired unit, and then each command addresses whichever Sorter was selected last.

The SELS command includes a test for READY.

*SELECT SORTER

Op	V	L	X/Y	A/B
S E L S			X	A
			Y	J

Jump is to the instruction whose address is "J" + (contents of RY).

*SELS: Select a Sorter.
(A) or "A" is unit number: 0-3
Only RH 2 bits are used.
Jump if unit is READY.

Processor hangs up if:
Two or more units assigned same number;
No unit assigned this number;
Power turned off in this unit.

*SET and CLEAR Unit Demand Flags

Op	V	L	X/Y	A/B
S E T U	S		X	A
			0 0	

Op	V	L	X/Y	A/B
C L R U	S		X	A
			0 0	

The second line of the instruction formot is not used. It is suggested thot zeros be entered in the Y column to indicote on o coding sheet thot this is o double-stoge instruction.

*SETU:S Set
*CLRU:S Clear } Unit Demand in Sorter.
(A) or "A" is unit number: 0-3
Only RH 2 bits are used.

Processor hangs up if:
Two or more units assigned same number;
No unit assigned this number;
Power turned off in this unit.

EXPLANATION OF BRANCHES—READ A CHECK

JY Transport jam. Whenever a check is not properly synchronized while being carried through the Sorter, the mechanism immediately opens.

The Buffer is forced into the READY state, and interrupt will occur if the Unit Demand and Demand Permit flags are set. Execution of the RCK instruction will transmit whatever information happens to be in the buffer at the moment, and this must be discarded since it does not necessarily comprise all the information from a check.

JY+1 Too late to read. Once the Buffer is loaded with information from a check, it will accept no further information until it has been completely unloaded into the Processor memory. Therefore if, through programming error, a RCK instruction is not issued soon enough, part of the information from the next check will fail to enter the buffer, so that its information will be incomplete and probably garbled.

When the RCK is executed for the *incomplete* check, that instruction will take this branch. Even though this check will go into the Reject pocket without attention from the program, it must be specifically pocketed there. Failure to pocket this check will set the "too late to sort" condition, and the PKT command for the *next* check will branch.

JY+2 Reading error. Explained on page 4.

START SORTER

Op	V	L	X/Y	A/B
S T R T	S			
			0 0	

The second line of the instruction format is not used. It is suggested that zeros be entered in the Y column to indicate on a coding sheet that this is a double-stage instruction.

The instruction automatically addresses itself to whichever Sorter was last selected by SELS.

If the Feed switch on this Sorter is on, this Sorter starts passing documents in continuous flow, and continues until either a STOP:S command is received, or one of several conditions arises in the Sorter itself; in the latter case, once the condition has been corrected, the operator restarts the Sorter from its own control console:

- The feed-stacker becomes empty. The operator loads more checks into it, and restarts the Sorter.
- The Feed switch is turned off. The Sorter resumes passing documents when the switch is turned on again.
- One of the 12 sorting pockets becomes full. The operator empties it, and restarts the Sorter.
- Transport jam. The operator clears the jam, and restarts the Sorter.
- Processor error-halts or executes a HALT instruction.

READ a CHECK

Op	V	L	X/Y	A/B
R C K			X	A
			Y	

JY is the beginning of a 3-way Jump Table.
Link in J14.

This instruction automatically addresses itself to whichever Sorter was last selected by SELS.

Read 28 slabs (56 characters) from the selected Sorter Buffer into the A-area of the Processor memory.

If the selected Buffer is not READY, the Processor waits until it becomes READY.

Processor error-halts and Reader stops feeding if anything but exactly 56 characters are received from the Buffer.

BRANCHES:

JY Transport jam.

JY+1 Too late to read.

JY+2 Reading error.

The instruction is always completed, and the full 56 characters are transferred to the Processor, before taking a branch.

If two or more conditions arise while reading a single check, the Processor will take the lowest-numbered of the appropriate jumps.

Because of the possibility of multiple jump conditions, the Processor records *all* conditions in Index Register R30 after *any* jump.

R30:

Undisturbed if no jump is taken.

After any jump, the Processor records *all* existing jump conditions in R30. Each of the three conditions is represented by a number, and the contents of R30 will be the sum of those numbers for which jump-conditions arose:

JY	00 020
JY+1	00 010
JY+2	00 008

POCKET a CHECK

Op	V	L	X/Y	A/B
P K T			X	A
			Y	

Jump is to address in JY.
Link in J14.

This instruction automatically addresses itself to whichever Sorter was last selected by SELS.

The RH Digit of the 1-slab A-word is transmitted to the Sorter, and designates which pocket is to receive the check which the Processor has just read from the Buffer.

Digit	*Pocket*
0 — 9	0 — 9
@	Reject
,	Reject
/	Reject
&	Reject
.	Special
—	Reject

JY: Jump if too late to pocket. If the program has not transmitted a pocket-digit in sufficient time, the check is sent to the Reject pocket, and the PKT instruction takes this branch.

STOP SORTER

Op	V	L	X/Y	A/B
S T O P	S			
			0 0	

The second line of the instruction format is not used. It is suggested that zeros be entered in the Y column to indicate on a coding sheet that this is a double-stage instruction.

This instruction automatically addresses itself to whichever Sorter was last selected by SELS.

The selected Sorter is stopped. More checks will still be in transit through the Sorter, and the program must read these from the Buffer, and pocket them, after issuing this instruction.

OPTICAL CHARACTER READER

OPTICAL CHARACTER READER

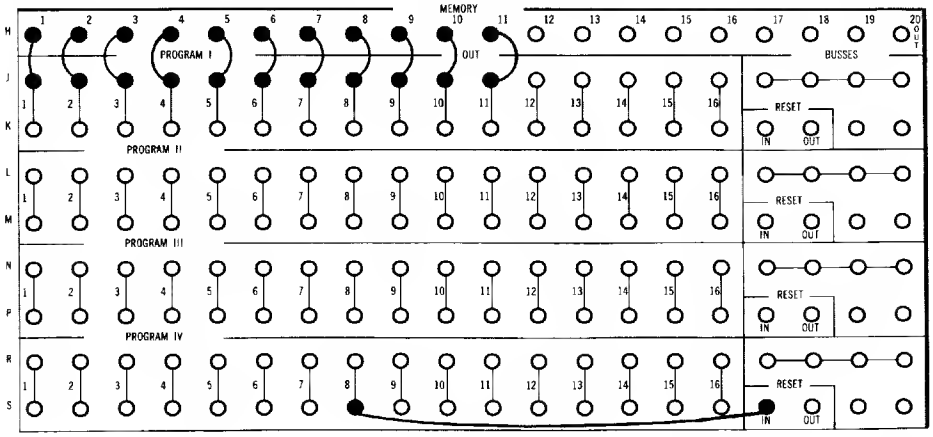
The NCR 315 Processor can operate up to 4 Optical Readers, and keep them all operating at full speed. The readers are connected to the Processor through the MICR Sorter-Reader trunk. Any combination of MICR Sorter-Readers and Optical Readers, up to 4, may be used.

The Optical Reader will read adding machine tapes, cash register tapes, Class 2000 store-type register tapes, and adding machine tapes produced on accounting machines, at the rate of 26 lines per second.

Each line on the tape may contain up to 32 positions, and the Reader selects any 20 of these (containing digits or one of the six special characters) to be stored in its buffer. The plugboard may be programmed (wired) to re-arrange the sequence of characters if desired, and may also be programmed to emit additional fixed characters from the Reader buffer to the Processor. Under this plugboard control, the Reader also emits additional zeros, so that a total of 56 characters are transmitted from the Reader buffer to the Processor. In order to do this, programs 1, 2, 3, and the first 8 steps of program 4 are tied together to make a single 56-step program. Reference should be made to the Optical Character Reader Manual (MD 420-1) for plugboard programming procedures.

In the following example, we suppose that 11 characters from the tape have been read into the first 11 positions of the Reader buffer. These buffer positions are then wired to the first 11 positions, respectively, of program 1. The rest of program 1, all of programs 2 and 3, and the first 8 steps of program 4, being unwired, will automatically emit zeros to the Processor. The out-hub of this last step (position S8) is wired to Reset In (position S17) to terminate the readout program.

If fill-digits other than zeros are wanted, they may be wired in from the Symbol emitters.



Any two of the 32 positions may be designated on the plugboard as "decision" columns, although these need not be stored in the Reader buffer or transmitted to the Processor. Any set of characters in either of these columns, or any combination of characters in the two columns, can be programmed to inhibit transmission of the entire line to the Processor. An inhibited line will be discarded by the Reader buffer, and the Processor will not receive an interrupt signal for that line.

Since the Optical Reader connects to the Processor through the Sorter trunk, it does not require any new Processor instructions, but responds to some of the Sorter-Reader instructions.

*SELECT SORTER (Optical Reader)

Op	V	L	X/Y	A/B
S E L S			X	A
			Y	J

Jump is to the instruction whose address is "J" + (contents of RY).

*SELS: Select an Optical Reader or Sorter.
(A) or "**A**" is unit number: 0-3
Only RH 2 bits are used.
Jump if unit is READY.

*SET and CLEAR Unit Demand Flags

Op	V	L	X/Y	A/B
S E T U	S		X	A
			0 0	

Op	V	L	X/Y	A/B
C L R U	S		X	A
			0 0	

The second line of the instruction format is not used. It is suggested that zeros be entered in the Y column to indicate on a coding sheet that this is a double-stage instruction.

*SETU:S Set
*CLRU:S Clear
} Unit Demand in Optical Reader or Sorter.

(A) or "**A**" is unit number: 0-3
Only RH 2 bits are used.

READ a CHECK (a Line)

Op	V	L	X/Y	A/B
R C K			X	A
			0 0	

The second line of the instruction format is not used. It is suggested that zeros be entered in the Y column to indicate on a coding sheet that this is a double-stage instruction.

This instruction automatically addresses itself to whichever Optical Reader or Sorter was last selected by SELS.

Read 28 slabs (56 characters) from the selected Buffer into the A-area of the Processor memory.

If the selected Buffer is not READY, the Processor waits until it becomes READY.

Since there are no jump conditions with the Optical Reader, the JY designation in this instruction is irrelevant.

R30:

Undisturbed.

If any of the instructions:

STRT:S

PKT

STOP:S

should be addressed to an Optical Reader, they have no effect whatever.

The Optical Reader is started, not under Processor control, but by means of a button on the Optical Reader. As each line is read into the Reader's buffer, the "decision" columns are examined to see if this line should be discarded.

1. If this line is not wanted, on the basis of the "decision" columns, the Reader clears its buffer and proceeds to read the next line on the tape.
2. If this line is wanted, the Reader becomes READY, and (if its Unit Demand flag is on) sends a Demand Signal to the Processor. If the Processor's Demand Permit flag is on, Demand Interrupt occurs; the Processor selects the Reader with SELS, and reads its memory with RCK.
3. If, for any reason, the Processor does not read the buffer by the time the Reader reaches the next line (within 3 milliseconds), no information is lost; the Reader stops in position to read the next line. Whenever the Processor does read the buffer, the Reader automatically starts again, and then reads the next line.

The Optical Reader recognizes a 16-character set of configurations. These consist of the digits 0 through 9, plus six special characters which are stored in the Processor as non-decimal digits. These are:

Name	Configuration	Character
"10"	⊞	@
"11"	⊬	,
"Y"	⊻	≠
"P"	⊩	&
"D"	⊣	•
"spade"	⊥	—

If the Reader should find some character which it cannot identify, it stops the tape, backs it up, and tries again. If, after 7 tries, it still cannot read the line, it stamps an ink-mark on the back of the tape, discards that line, and continues reading. The Processor, of course, is not involved in the Reader operation all the time. The Reader's console contains a counter to show the number of lines that were rejected, and these can be located on the tape by means of the ink-marks, and entered by other means.

The Reader contains two facilities for manually entering occasional information, such as batch number, register number, etc. There is a row of 20 dial switches on the console, by which the operator may enter one or more complete lines into the Reader's buffer, and thence to the Processor. There is another set of 4 dial switches, which may be read-out with each line, as specified in the plugboard program, and transmitted to the Processor as part of the group of emitted characters.

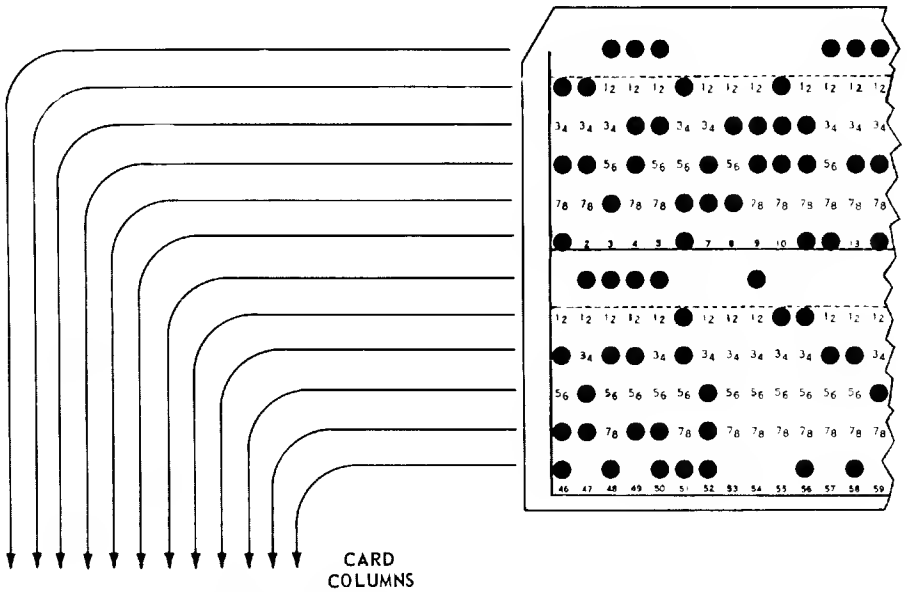
90-COLUMN CARD READER

90-COLUMN CARD READER

400 cards per minute

An optional model of the 400 card-per-minute Reader will read 90-column Remington Rand punched cards. The operation of the RCϑL:F and RCϑL commands with this Reader are precisely the same as for the 80-column Reader, except that the N of the command now refers to column-pairs; there are 45 column-pairs to a card, and the image of a card in memory occupies 45 slabs:

SLABS	0		1		2		3		4		5		41		42		43		44	
CARD COLUMNS	1	46	2	47	3	48	4	49	5	50	6	51	42	87	43	88	44	89	45	90



CARD COLUMNS														CARD COLUMNS
1	0	1	0	1	0	1	0	0	1	0	1	1		46
2	0	1	0	1	0	0	1	0	0	1	1	0		47
3	1	0	0	0	1	0	1	0	1	0	0	1		48
4	1	0	1	1	0	0	1	0	1	0	1	0		49
5	1	0	1	0	0	0	1	0	0	0	1	1		50
6	0	1	0	0	1	1	0	1	1	0	0	1		51
7	0	0	0	1	1	0	0	0	0	1	1	1		52
8	0	0	1	0	1	0	0	0	0	0	0	0		53
9	0	0	1	1	0	0	1	0	0	0	0	0		54
10	0	1	1	1	0	0	0	1	0	0	0	0		55
11	0	0	1	1	0	1	0	1	0	0	0	1		56
12	1	0	0	0	0	1	0	0	1	0	0	0		57
13	1	0	0	1	0	0	0	0	1	0	0	1		58
14	1	0	0	1	0	1	0	0	0	1	0	0		59

Bit-patterns in successive slabs of memory

FEED a Punched Card and READ Columns
READ Columns from a Punched Card

400 card per minute reader (90 columns)

Op	V	L	X/Y	A/B
R C Θ L	F		X	A
			Y	N

Op	V	L	X/Y	A/B
R C Θ L			X	A
			Y	N

Jump is to address in JY.
Link in J14.

Punched cards are read serially, column-pair by column-pair, beginning with card-columns 1 and 46. N column-pairs of a card are read into memory, starting at the LH end of the A-area.

N may be 000-089.

The image of each column-pair is stored as a bit-configuration in one slab of memory, with 1-bits corresponding to holes in the card (see illustration on the opposite page). After reading, the program must translate each bit-configuration into the actual character. Standard sub-routines and macro-instructions are furnished for this purpose.

It is customary to read and translate one column-pair at a time, since there is sufficient time between card columns to perform the table-lookup while the card is passing.

When the leading edge of each card reaches the reading station, the Card Reader will exercise Demand if the Processor's Demand Permit flag is on. Note that there is no Unit Demand flag in the Card Reader, and when reading cards, all other Unit Demand flags will usually be turned off.

RCΘL:F Feed a card, read N columns.

If N = 0, feed only; do not test for previous *missed column.*

If a FEED is issued after columns 1/46 and before columns 14/59 of the present card, then the Reader will remain in *continuous feed* and the next card will be fed with minimum interval between cards.

A FEED issued before columns 1/46 can apply only to the present card. If this card has already been fed, the new FEED does nothing.

RCΘL: Read N columns.

If N = 0, this instruction does nothing.

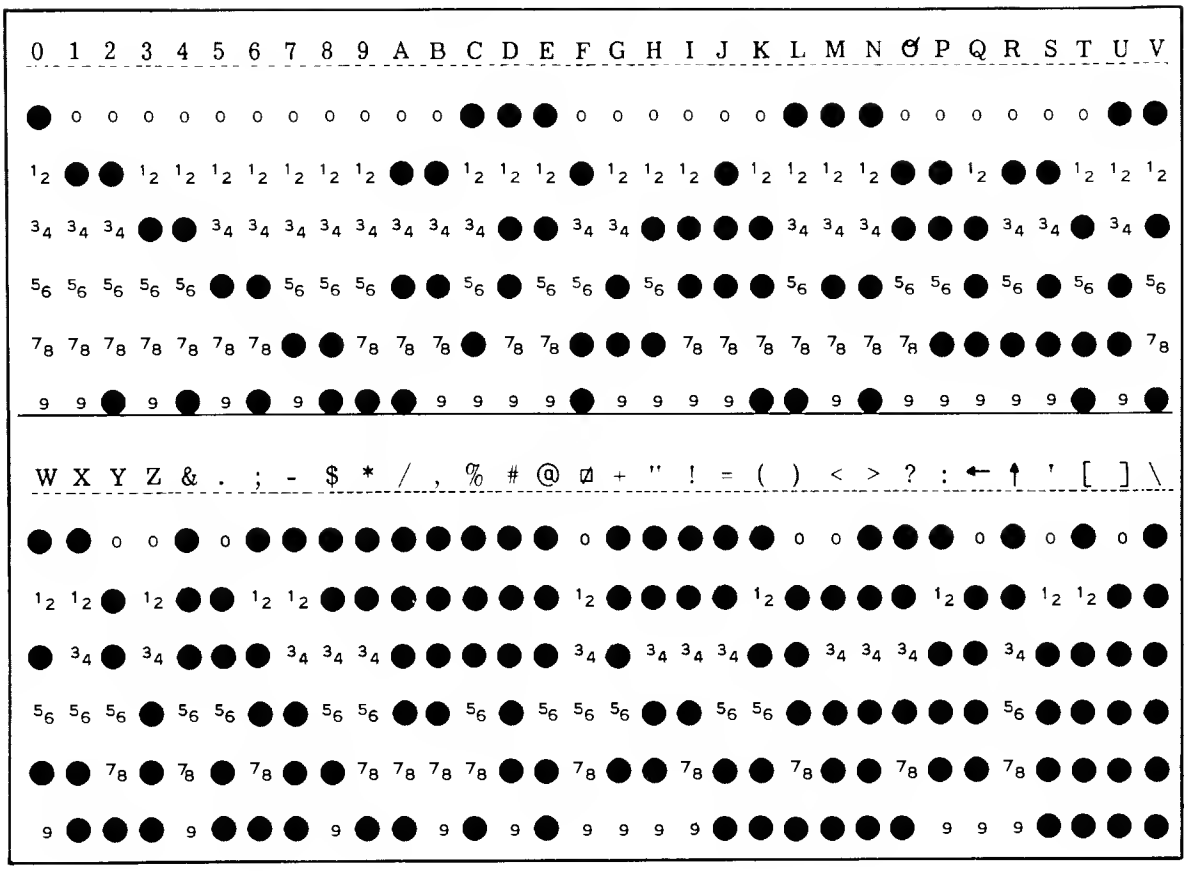
JY:
Missed-column jump. Branch without execution. One or more column-pairs of the present card have passed the reading station without being captured by an RCΘL or RCΘL:F instruction. The current instruction will not be executed, but will branch instead to the address named in JY.

Only the instruction RCΘL:F with N = 0 may be executed when the missed-column condition exists. This instruction will not branch; it *will* set the feed signal for the next card.

The missed-column condition is automatically reset when the trailing edge of the card passes the reading station. Thus reading may terminate when the desired portion of a card has been read, and resume with the next card without encountering the JY branch.

Processor hangs up if input stacker empty, if a card is mis-fed, if power off in Reader, or if the instruction calls for reading columns from a card that has not been fed.

PUNCHED CARD CODE



CARD CHARACTER	IMAGE IN 315
0	+
1	!
2	A
3	8
4	9
5	4
6	5
7	2
8	3
9	1
@	>
'	'
≠	0
&	Y
•	"
—	P
!	U
A	E
B	D
C	K
D	$
E	Q

CARD CHARACTER	IMAGE IN 315
F	C
G	6
H	@
I	≠
;	(
"	W
?	V
:	)
←	←
↑	*
+	<
J	?
K	&
L	J
M	M
N	N
O	H
P	;
Q	•
R	B
%	Z
=	T

CARD CHARACTER	IMAGE IN 315
$	S
(	=
)	:
/	[
*	#
#	]
S	F
T	'
U	O
V	R
W	%
X	L
Y	I
Z	7
<	G
>	X
'	—
[	/
]	↑
\	\

IMAGE IN 315	CARD CHARACTER
0	≠
1	9
2	7
3	8
4	5
5	6
6	G
7	Z
8	3
9	4
@	H
'	T
≠	I
&	K
•	Q
—	'
!	1
A	2
B	R
C	F
D	B
E	A

IMAGE IN 315	CARD CHARACTER
F	S
G	<
H	O
I	Y
;	P
"	•
?	J
:	)
←	←
↑	]
+	0
J	L
K	C
L	X
M	M
N	N
O	U
P	—
Q	E
R	V
%	W
=	(

IMAGE IN 315	CARD CHARACTER
$	D
(	;
)	:
/	[
*	↑
#	*
S	$
T	=
U	!
V	?
W	"
X	>
Y	&
Z	%
<	+
>	@
'	'
[	/
]	#
\	\

UNBUFFERED PRINTER AND BUFFERED NUMERIC LISTER

UNBUFFERED PRINTER AND BUFFERED NUMERIC LISTER

This Printer will operate as:

Unbuffered alphanumeric printer (alpha mode) ..... 650 lines per minute
Unbuffered numeric printer (numeric mode) ..... 805 lines per minute
Buffered 24-position numeric lister (list mode) .....1850 lines per minute

The Printer may be equipped with either of the following type-lines:

A. Standard type-line, with 120 alphanumeric positions across the page. Does not operate as buffered lister with this type-line.
B. Lister type-line with:
   96 alphanumeric positions at the left of the page,
   24 numeric-only (plus hyphen and space) positions at the right of the page.

These type-lines are interchangeable, and the change is made by operating personnel.

The principal modes of operation used with the Unbuffered Printer are:

1. Alpha, slew-after. Paper movement is time-shared, and the Processor is free to edit each line during slew for the previous line. The effective rate is 650 printed lines per minute.
2. Alpha, slew-before. There is no time-sharing at all; computing time must be added to printing time, to give an effective rate of less than 650 lines per minute. However, this mode is compatible with the Buffered Printer, and the two printers may be used interchangeably with the same programs.
3. Numeric, slew-after. This is a synchronous mode in which one line is printed with each revolution of the print cylinder, and there is very substantial time-sharing. The printing rate is the same as the revolution rate—805 lines per minute.
4. List, slew-after. This is a completely buffered operation, designed primarily to operate with the 1620-document-per-minute MICR Sorter. The output rate in this configuration is the speed of the Sorter—1620 lines per minute. When printing from magnetic tape or from CRAM, the rate is 1850 lines per minute.

PRINT (Unbuffered Printer)

Op	V	L	X/Y	A/B
P R N T			X	A
			Y	M F

This digit always zero

M is Mode.
F is Vertical Format Control.
JY is beginning of 2-way Jump Table.
Link in J14.

SET PRINTER MODE:

This command must always be *immediately preceded* by a SELP command, even if this Printer is already selected.

This command, with F *equals zero* and M *not zero,* is interpreted by the Unbuffered Printer as a SET MODE command, with X and A irrelevant. Once the mode has been set, the Printer remains in that mode until it receives another PRNT command with F = 0 and M ≠ 0.

M = 1 alpha
M = 2 list
M = 3 numeric

PRINT:

This command must always be *immediately preceded* by a SELP command, even if this Printer is already selected.

The location addressed by XA is the first (LH) slab of the edited print line in memory. F is the slew control and M is the mode of slew control. The JY+1 non-printing option is not available with the Unbuffered Printer, and the values of M are:

M = 0 or 2: F is number of lines,
M = 1 or 3: F is recognition code.

If M is 0 or 2, then F is the actual number of lines the paper is moved. If F is a non-decimal digit, then:

F	means
@	10
,	11
⌀	12
&	13
•	14
–	15

M = 0, F = 0 means do not move paper at all; this will cause two consecutive lines to be overprinted.

If M is 1 or 3, paper is moved until a punched configuration on the VFU tape (Vertical Format Unit, see below) exactly matches the bit-configuration of F, where holes in the tape correspond to 1-bits of F. Do not use *period* as a recognition code, as this is reserved for possible special function in future model printers.

If there is no VFU configuration that matches F, the Printer moves paper until the VFU "special" code (punches in 8-4-2-1) is reached the *second* time. Paper movement then stops, and the Printer error-halts.

STANDARD TYPE-LINE

Alpha mode. When the Printer has been set to the alpha mode, the PRNT command delivers the 120-character (60-slab) print line from the Processor memory to the Printer 56 times, once for each sector on the print cylinder.

The surface of the print cylinder is divided into 56 printing sectors, corresponding to the 56 printable characters. Sector *zero* is a row of 120 zeros, sector *one* is a row of 120 ones, etc. Each time the 120-character print line is presented to the Printer, it is scanned to see which positions (if any) contain the character for the current sector; whenever that character is found, the print hammer for the corresponding position is energized.

If one of the 8 non-printing characters occurs in the print line, it will appear on the printed page as a capital letter, overprinted with a *plus* sign:

Character	Printed as
?	M
:	N
←	O
↑	P
'	U
[	V
]	W
\	X

Numeric mode. When the Printer has been set to the numeric mode, the Processor waits in the PRNT command until just before the zero-sector on the print cylinder is about to come into position. The command then delivers the 120-character print line from the Processor memory to the Printer 16 times, once for each of the sectors *zero* through *hyphen* on the print cylinder. The Processor is then free.

If the print line contains any character whose zone bits are not both 0-bits, that character will not be printed, and its position on the line will be blank.

LISTER TYPE-LINE

Alpha and Numeric modes. The LH 96 positions of the line may contain any characters appropriate to the mode, but the RH 24 positions may contain only the 10 digits, hyphen, and space. If any other character appears in memory in one of these 24 positions, it will print as one of these 12 characters.

Remember

The hyphen, in the RH part of this type-line, is in the @-sector. Therefore to print a hyphen in one of these 24 positions in the alpha or the numeric mode, the print line in memory must contain the character @.

List mode. The PRNT command addresses a 24-character (12-slab) print line in memory. These 24 characters are stored in the Printer's buffer, and the Processor is immediately free. The printed information appears in the RH 24 positions of the page. These positions each contain the 12 characters repeated five times around the circumference of the print cylinder, and printing with single-line slew occurs more than twice as fast as the print cylinder revolves.

Remember

It is essential that the 25th character in memory (the LH character of the slab immediately following the 12 that compose the print line) must have a 1-bit as its LH zone bit.

When the characters hyphen and space are to be printed, those actual characters appear in the print line in memory (in contrast to the special requirement for hyphen in these 24 positions in the alpha and numeric modes). If any of the four "numeric" characters ,@, &, *comma, period,* appear in the print line in memory, they will not be printed — their positions will be left blank on the page.

If any character in the print line in memory contains 01 as its zone bits, it will be treated as though its zone bits were 00.

If any character in the print line in memory contains 10 or 11 as its zone bits, that character will not be printed, and *all characters to its right* will also be dropped; their positions will be left blank on the page.

The presence of a buffer in an "unbuffered" Printer may arouse some curiosity, and it may be interesting to know how it happens to be present.

When the Printer is operating in the unbuffered modes, then for each sector the 120 characters of the print line are delivered to the Printer serially, over an interval of 1.2 milliseconds, between sectors. As each character in turn is examined to see if it matches the next sector, the corresponding one of 120 storage elements in the Printer is turned on or off to record the result of the comparison. Then, just as the sector arrives, all print hammers corresponding to *on*-elements are energized simultaneously.

In the buffered lister mode, with only 24 positions being printed, only 24 of these 120 storage elements are used for this purpose. The other 96 elements are then grouped in fours, to form a storage buffer for 24 digits of 4 bits each.

VERTICAL FORMAT CONTROL:

The Vertical Format Unit (VFU), which is part of the Printer, holds a loop of paper tape into which 15 different code-configurations can be punched. The loop is the same length as the form being printed, and the punched codes correspond exactly to the lines which they designate.

As the paper moves vertically, the VFU tape loop moves with it so that paper movement is controlled by the VFU tape as specified by M and F in the command.

There is a switch on the Printer, to determine whether it shall move paper before, or after, printing each line. If this switch is set to *slew-before,* then in the alpha and numeric modes the Processor is tied up during paper movement as well as during printing. If this switch is set to *slew-after,* then in these modes the Processor is free as soon as the line is printed, and paper movement is time-shared. In the list mode, Printer operation is always completely buffered, and the choice of slew-before, or slew-after, is largely a matter of programmer's preference.

SELECTION OF PRINTER:

Any PRNT command (whether "Set Printer Mode" or an actual Print operation) addressed to an Unbuffered Printer must always be *immediately preceded* by a SELP command, even if this Printer is already selected.

JUMP EXITS:

JY. If paper movement for any PRNT command reached or passed a "special" configuration on the VFU tape (all four punches in 8-4-2-1), and if this is *not* the last page of continuous-form paper, then the JY indicator is set in the Printer.

- In the alpha and numeric modes, the next PRNT command,
- In the list mode, the PRNT command after that,

will take the JY branch (and turn off the JY indicator) *instead* of being executed.

JY+1. If paper movement reached or passed a "special" configuration, but if this *is* the last page of continuous-form paper, then the JY+1 indicator is set in the Printer instead.

- In the alpha and numeric modes, the next PRNT command,
- In the list mode, the PRNT command after that,

will take the JY+1 branch (and turn off the JY+1 indicator) *after* being executed.

Note that any PRNT command addressed to an Unbuffered Printer might cause the JY indicator *or* the JY+1 indicator to be set, but never both.

DEMAND INTERRUPT:

Alpha and Numeric modes. There is no demand interrupt in these modes. Placing the Printer into the alpha or the numeric mode automatically turns off the Unit Demand flag, and if the program should attempt to set the flag while the Printer is in either of these modes, the Processor will hang-up.

List mode. There is full demand interrupt facility in the list mode, with full freedom to set and clear the Unit Demand flag. Whenever the Printer is ready it will send the Processor a demand signal if the Unit Demand flag is on; if the Processor's Demand Permit flag is also on, interrupt will occur.

STANDARD PUNCHING FOR VERTICAL FORMAT TAPE:

The following conventions have been adopted for punching the VFU tape, assuming a page 11 inches high:

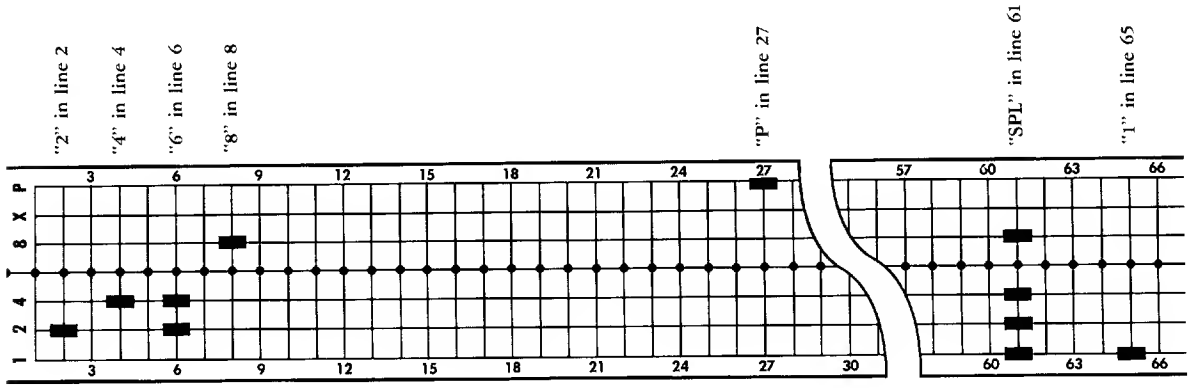
1. A punch in the P-column on VFU line 27.
   After loading paper in the Printer's rear tractors, the operator presses the SET LOOP button, advancing the paper into the front tractors and moving the VFU tape to the P-punch. Then the operator moves the paper so that the page-perforation is aligned with the Printer's perforation guide. The paper is now aligned with the VFU tape, so that line 1 on the tape corresponds to the first printing line on the page.
2. Punch configurations 2, 4, 6, 8 on VFU lines 2, 4, 6, 8 respectively.
3. Punch "special" (8-4-2-1) on VFU line 61.
4. Punch configuration 1 on VFU line 65.

The requirements of specific printed forms, or the use of a page longer or shorter than 11 inches (66 lines), may indicate the placing of "special" and "1" at somewhat different positions. Also, any *other* configurations may be punched elsewhere on the tape to provide additional format control. These changes will still permit the VFU loop to be used for Compiler listings and other service routine printouts.

However, the loop may not be used as standard for these purposes if any of the specified configurations is repeated elsewhere on the tape.

Do not use punch configuration 8-4-2, as this is reserved for possible special function in future model printers.

STANDARD PUNCHING for VERTICAL FORMAT TAPE



TIME SHARING, READY STATUS:

The following should be read in connection with the accompanying flow charts.

Alpha, slew-before. This mode uses the same program logic for vertical format as the Buffered Printer, except for slight changes in JY+1. Thus the same programs may be written to output interchangeably on either printer.

The SELP command always finds the Printer ready, except after a JY+1 jump.

The time to print one line is computing time plus slew time plus one revolution, and the printing rate will be somewhat less than 650 lines per minute, depending on the amount of time spent between lines in computation.

Alpha, slew-after. This mode requires the program to use different logic for vertical format, since the slew control in each PRNT command now applies to spacing below, rather than above, the line to be printed.

The Processor is free while the Printer is moving the paper, and will edit the next line during this interval. The program is expected to issue the next PRNT command while the Printer is not-ready.

The time to print one line is one revolution plus slew time, since computing is shared with slewing, and the printing rate for single-spacing will be 650 lines per minute.

Numeric, slew-before. A study of the flow chart will indicate that in this mode the Printer will produce one printed line every other revolution, to output 402 lines per minute. There is no point in using this combination of opinions; alpha slew-before will accomplish the same printing faster.

Numeric, slew-after. A substantial portion of the revolution-time is available to the Processor to edit the next line, and do other computation, while maintaining printed output at the rate of one line per revolution. The SELP command will find the Printer ready whenever slewing has been completed.

The time to print one line is one revolution. Printing, computing, and slewing are all performed in this time, and the printing rate for single-spacing (or even triple-spacing) will be 805 lines per minute.

List, slew-before. In this mode the Printer becomes ready as soon as it has printed a line. This mode is theoretically a trifle slower than slew-after, since loading the buffer is not shared with paper movement. However, the List modes will usually be used with the MICR Sorter, and obviously information cannot be printed faster than it is being made available; therefore both List modes will operate at the speed of the Sorter — 1620 documents per minute

Note that in this mode the Printer will always print *two* lines on or below a VFU special, before giving the JY or JY+1 indication to the Processor. If JY+1, the line after that will also be printed.

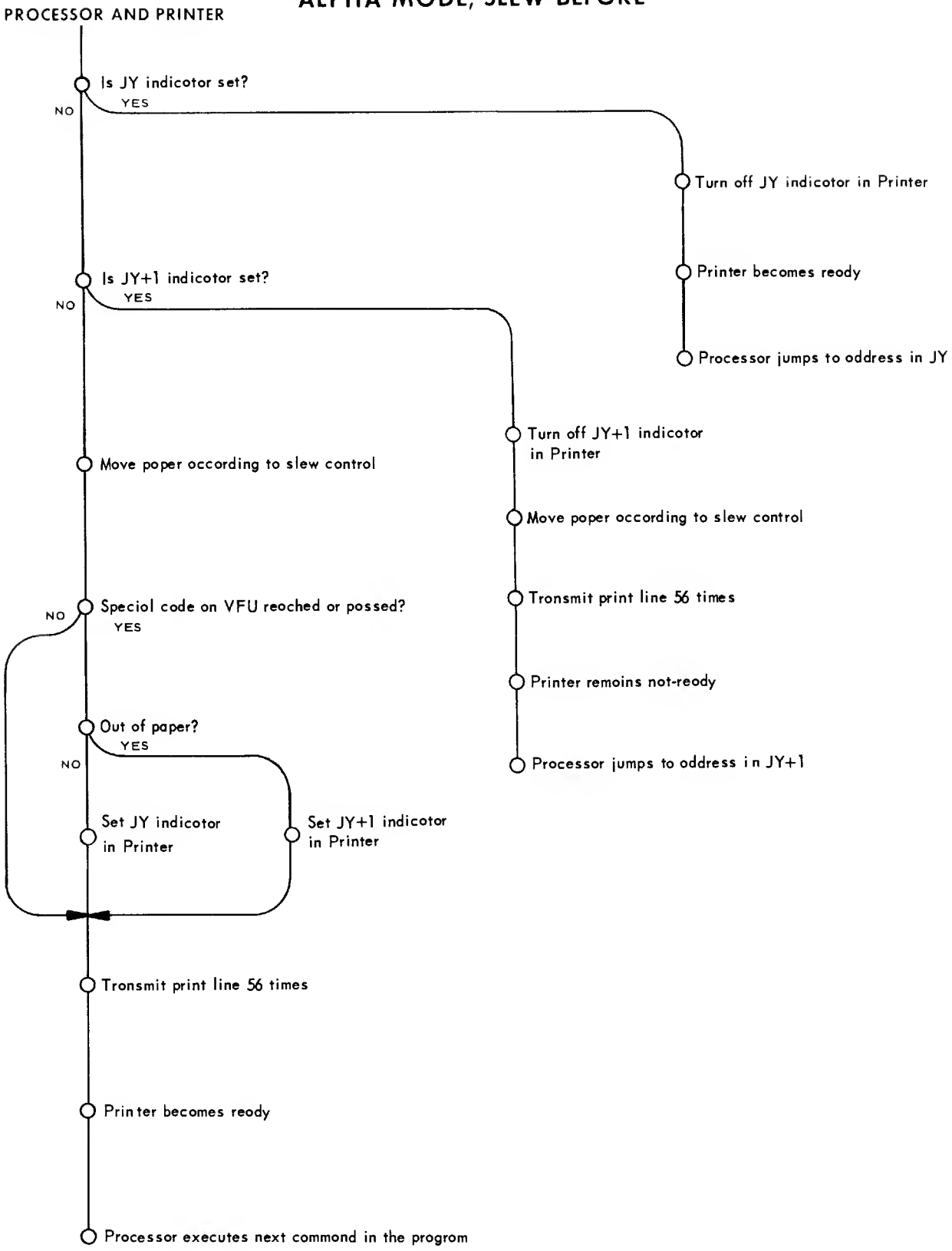
List, slew-after. In this mode the Printer becomes ready as soon as it has printed a line, and will accept a new line into its buffer simultaneously with beginning the slew, or at any time thereafter. In order to remove possible ambiguity as to which subsequent PRNT command will detect the JY and JY+1 indicators, two additional memory elements, flags A and B, have been placed in the Printer.

Note that in this mode the Printer will always print *one* line on or below a VFU special, before giving the JY or JY+1 indicator to the Processor. If JY+1, then the line after that will also be printed.

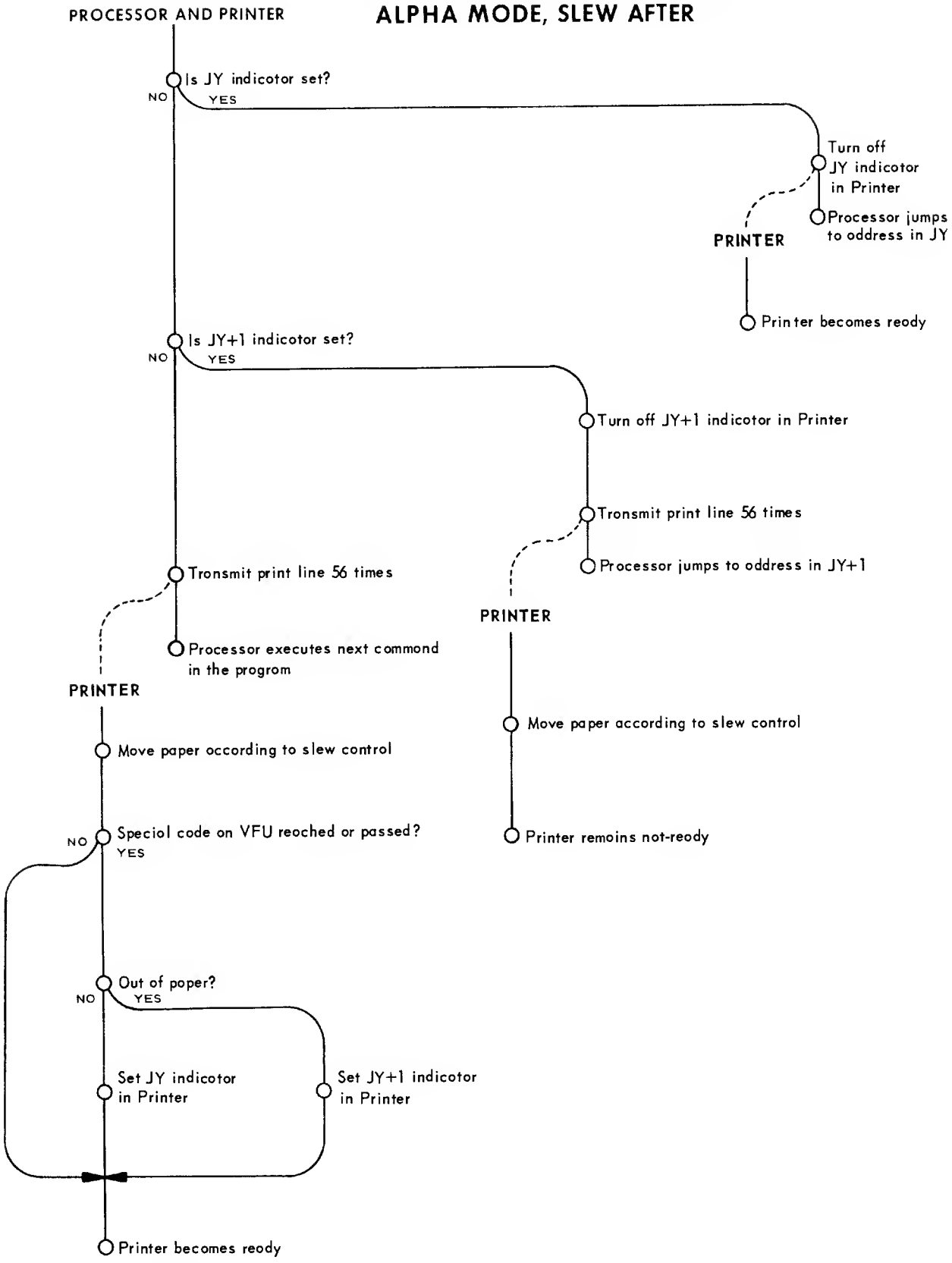
In either List mode, if slew for line "1" reaches or passes a VFU special, it will always be the PRNT command for line "3" that takes JY or JY + 1; if JY + 1, then line "3" will also be printed.

FLOW CHARTS OF UNBUFFERED PRINTER MODES

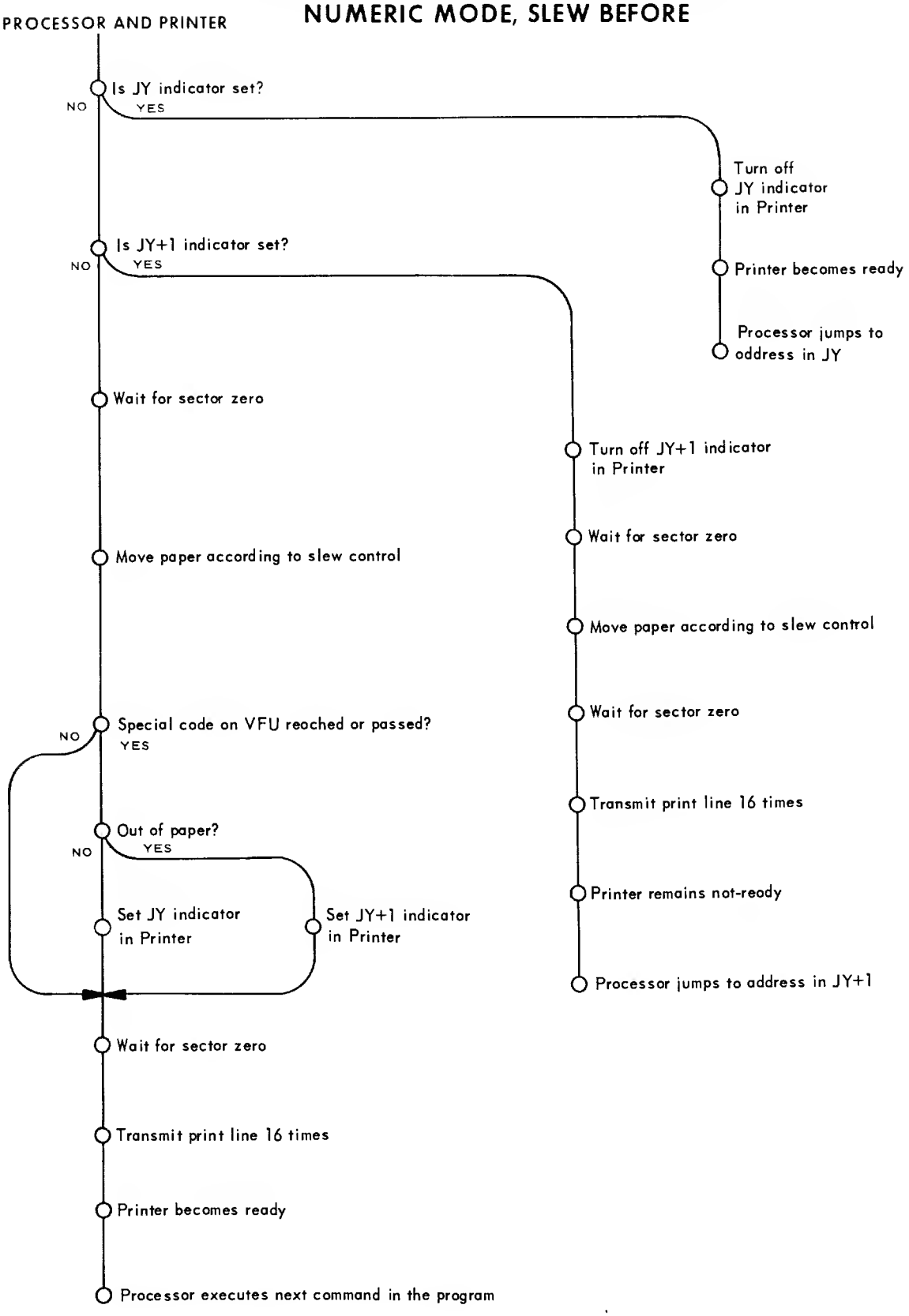
PRINT COMMAND (Unbuffered Printer)
ALPHA MODE, SLEW BEFORE



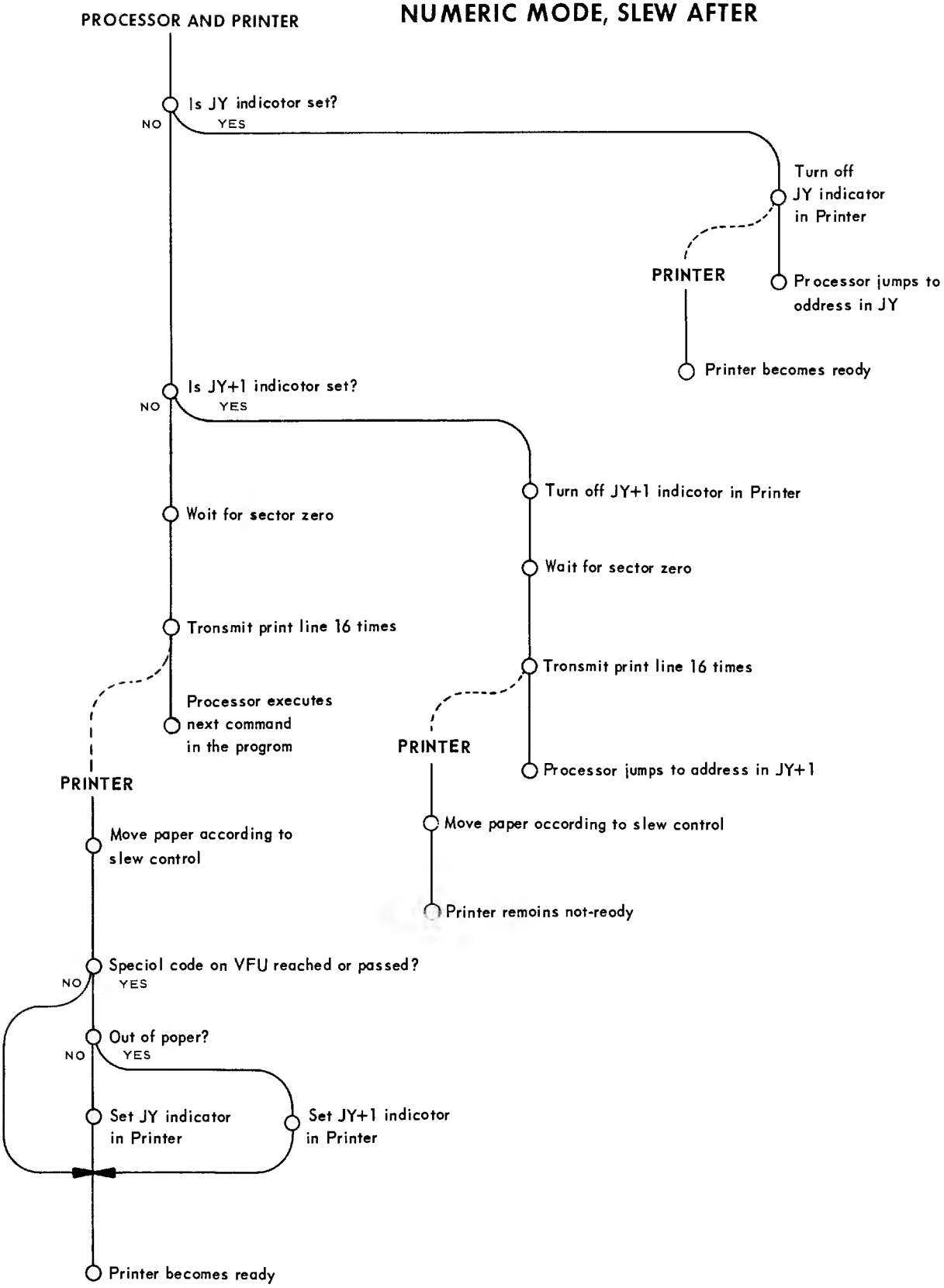
PRINT COMMAND (Unbuffered Printer)
ALPHA MODE, SLEW AFTER



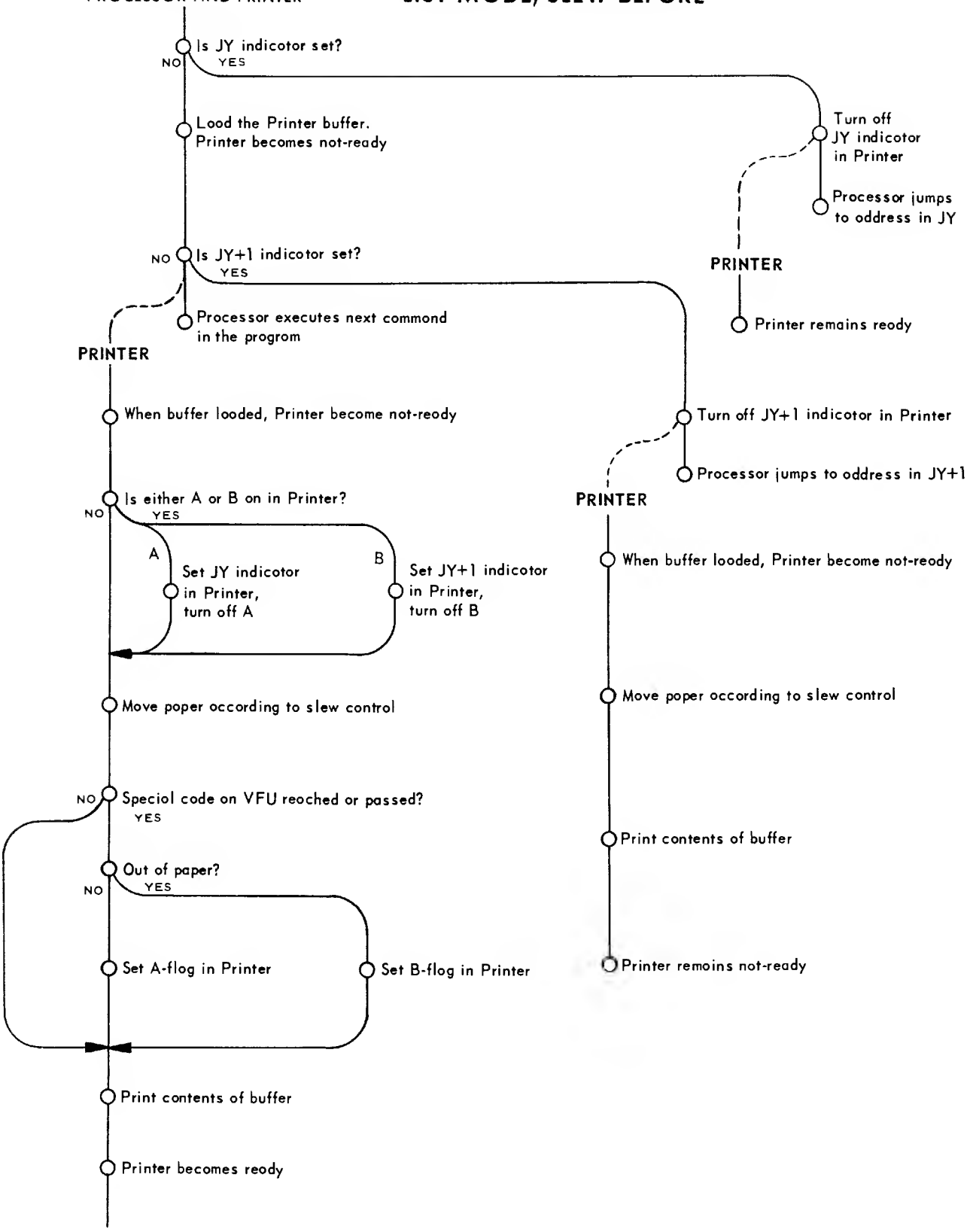
PRINT COMMAND (Unbuffered Printer)
NUMERIC MODE, SLEW BEFORE



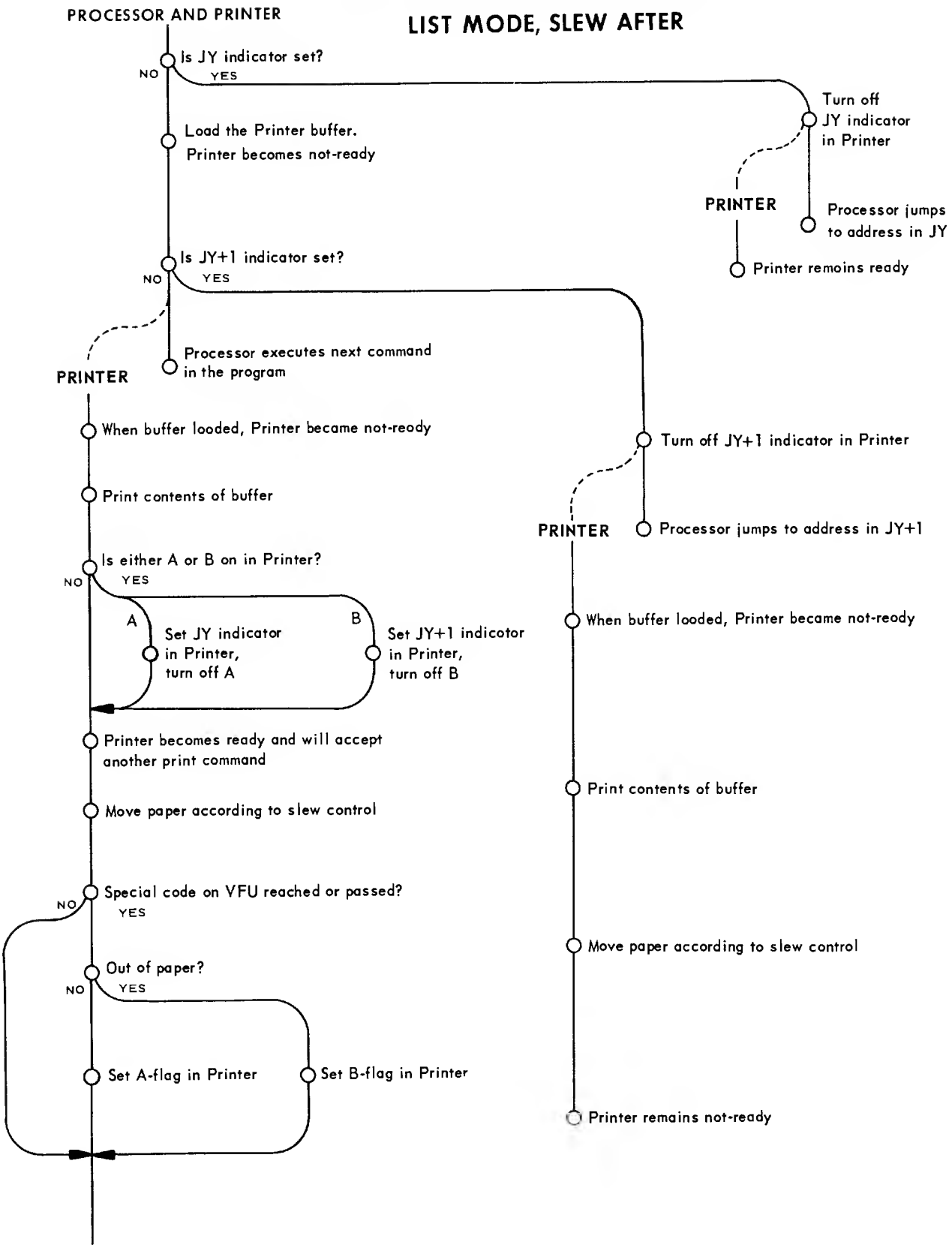
PRINT COMMAND (Unbuffered Printer)
NUMERIC MODE, SLEW AFTER



PRINT COMMAND (Unbuffered Printer)
LIST MODE, SLEW BEFORE



PRINT COMMAND (Unbuffered Printer)
LIST MODE, SLEW AFTER



READY STATUS AND DEMAND INTERRUPT

	READY		DEMAND SIGNAL Exercise Demand if Demand Permit flag on	
	ON	OFF	ON	OFF
BUFFERED PRINTER	Finished printing a line unless instruction took JY + 1	PRNT instruction loads the buffer	READY on and Unit Demand on	READY off or Unit Demand off
UNBUFFERED PRINTER Alpha, slew-before	Finished printing a line unless instruction took JY + 1	PRNT instruction	Never	Always
UNBUFFERED PRINTER Alpha, slew-after	Finished slewing unless instruction took JY + 1	PRNT instruction	Never	Always
UNBUFFERED PRINTER Numeric, slew-after	Finished slewing unless instruction took JY + 1	PRNT instruction	Never	Always
UNBUFFERED PRINTER List	Finished printing a line unless instruction took JY + 1	PRNT instruction loads the buffer	READY on and Unit Demand on	READY off or Unit Demand off
CARD PUNCH	Finished punching a card or Could not punch a card	PNCH instruction loads the buffer PNCH instruction takes branch	READY on and Unit Demand on	READY off or Unit Demand off
CARD READER	Card leading edge reaches reading station	Card column 1 reaches reading station	READY on	READY off
MICR SORTER-READER	A document is in the buffer or Transport jam	RCK instruction reads the buffer RCK instruction takes branch	READY on and Unit Demand on	READY off or Unit Demand off
OPTICAL READER	A line is in the buffer	RCK instruction	READY on and Unit Demand on	READY off or Unit Demand off
CRAM	Card in minimum access position AND Unit Demand on unless present card after SELC:DN	WCC or RCC instruction or card passed P.E. 3 or Unit Demand off	READY on (includes Unit Demand on)	SELC instruction or READY off

OPERATING TIMES OF 315 INPUT, OUTPUT, FILE DEVICES

All times are expressed in milliseconds (0.001 seconds)

Minimum (min) times establish safe computing time
Average times establish elapsed time

CARD READER

		MODEL		
400 cards per minute, 80-column or		400	400	2000
400 cards per minute, 90-column or		cpm	cpm	cpm
2000 cards per minute, 80-column		80-col	90-col	80-col
Reader at rest:				
Feed command till leading edge interrupt		45.0	45.0	30.0
	min	30.0	30.0	25.0
Computing time available:				
Interrupt till Read command for column 1	min	2.8	2.8	0.29
Between Column-Reads, beginning of the card	min	0.886[a]	1.676[b]	0.10
Between Column-Reads, rest of the card	min	1.086	2.036	0.10
Between cards:				
End of Read command for column 80 (or 45/90) till leading edge interrupt for next card		25.0[c]	25.0[d]	10.0[e]
	min	23.6[c]	23.6[d]	6.0[e]
Plus time for each card column not read		1.5	2.6	0.22
Duration of reading a card		117.0	117.0	20.0
Less time for each card column not read				
Elapsed time per card in free flow		150.0	150.0	30.0

[a] First 4 intervals.

[b] First 2 intervals.

[c] To maintain free flow in the 400 cpm 80-column Reader, the Feed for the next card must be given before reading column 25 of the current card. If the Feed is given after column 25, but not later than 19 ms after column 80, then the time from column 80 till next interrupt is 50 ms. If the Feed is not given within 19 ms after column 80, the Reader comes to rest.

[d] To maintain free flow in the 400 cpm 90-column Reader, the Feed for the next card must be given before reading column 14/59 of the current card. If the Feed is given after column 14/59, but not later than 19 ms after column 45/90, then the time from column 45/90 till next interrupt is 50ms. If the Feed is not given within 19 ms after column 45/90, the Reader comes to rest.

[e] To maintain free flow in the 2000 cpm 80-column Reader, the Feed for the next card must be given before reading column 60 of the current card. If the Feed is given after column 60, the time from Feed till next interrupt increases gradually until the Reader is at rest, which happens 15 ms after column 80.

The speed of card movement through the 2000 cpm Reader is always constant, but the interval between successive cards varies with the physical condition of the individual cards, with the amount of humidity to which they have been exposed, and even with their color (different dyes give the same paper stock different coefficients of friction). For this reason, the average reading rate for any given application will be relatively constant, but the rate from application to application may vary between 1800 and 2400 cards per minute.

PAPER TAPE READER

1000 characters per second

Start time		5.0
Computing time available between characters	min	0.785
Elapsed time per character		1.0

PAPER TAPE PUNCH

110 characters per second

	min	ave	max
Elapsed time per character	8.65	9.10	9.60
Command execution time, punch 1 character	4.04	4.25	4.46
Computing time available between characters	4.61	4.85	5.14

MICR SORTER READER

		MODEL	
750 documents per minute or		750	1620
1620 documents per minute		per min.	per min.
	min	78.4	36.26
Time between successive interrupts		80.0	37.04
	max	84.0	38.98
Time from interrupt till too late to Read	min	25.0	11.50
Time from interrupt till too late to Pocket	min	78.4	36.26
Duration of Read command		0.668	0.668
Plus 0.054 ms if JY branch			
0.060 ms if JY+1 branch			
0.066 ms if JY+2 branch			
Duration of PKT command		0.094	0.094
Plus 0.042 ms if JY branch			
Duration of START, STOP commands: each		0.060	0.060
START command till first interrupt	min	315.0	145.0
	max	420.0	195.0

After STOP command, there will be up to 5 more interrupts, caused by documents still in transit.

OPTICAL CHARACTER READER

26 lines per second

Time between successive interrupts		38.5
	min	36.0
Time from interrupt till Read command must be given to maintain free flow	min	4.0†
Duration of Read Command		0.668
Time from full stop till next interrupt		13.0

†If the program issues the Read command between 4 and 7 ms after interrupt, the reading rate will be reduced slightly, since the paper will begin to decelerate. After 7 ms the brake is engaged, and the paper stops

CARD PUNCH

100 cards per minute or
250 cards per minute

Command execution time (transmit information to buffer):

Translate mode (80 characters)	0.9
Direct mode (80 slabs)	1.7

Time available from interrupt till PNCH command must be given, in order to maintain full punching rate:

	MODEL	
	100 cpm	250 cpm
Translate mode	14.1	11.6
Direct mode	13.3	10.8

CONSOLE TYPEWRITER

10 characters per second

Elapsed time per character	100.0
Processor released during last character. Shareable time	70.0

BUFFERED PRINTER

690 lines per minute, alphanumeric
940 lines per minute, numeric
Cylinder revolution rate 940 RPM
Paper movement 5400 lines per minute

Time for one PRNT command:

Command execution time	0.12
Transfer information to buffer	1.22
	1.34

Alphanumeric information:

PROCESSOR		PRINTER		
PRNT command setup	0.12			
Information transfer	1.22	Information transfer	1.22	print one line 87.05†
Shareable time	85.71†	Slew 1 line	22.00†	
Next PRNT command	0.12	1 revolution	63.83	
Information transfer	1.22	Information transfer	1.22	

†Plus 11.11 ms per blank line

Numeric information:

PROCESSOR		PRINTER		
PRNT command setup	0.12			
Information transfer	1.22	Information transfer	1.22	one revolution 63.83
Shareable time	62.49	Slew 1 line	22.00	
		Wait for sector zero	22.37†	
Next PRNT command	0.12	Print 16 sectors	18.24	
Information transfer	1.22	Information transfer	1.22	

†Enough time for 1 blank line if desired

MAGNETIC TAPE

24,000 characters per second or
40,000 characters per second or
60,000 characters per second

Combined command setup, start, sum-check, and stop time:

Read or Write	9.4
Index Backward, following Write	413.0
Index Backward, following Read	408.0

To these times must be added the actual information time at the recording rate being used:

24 kc	0.0417 ms per character
40 kc	0.0250 ms per character
60 kc	0.0167 ms per character

Tape speed forward, all frequencies.....120 inches per second
Tape speed rewind.....240 inches per second

CRAM

Card drop time, from Drop command till PE 2 interrupt.....235.0
min 170.0

There is an interval of 150 ms, after a dropped card reaches PE 2, during which the CRAM will accept and store the next Drop command, then begin to execute it at the end of that interval.

Return of released card: Last PE 3, Read or Write, through gate, along raceway, into chamber.....250.0

PE 2 till PE 3		2.45	one revolution 46.12
Blank at beginning of track	0.72		
Write head to Read head	1.25		
1550 slabs @ 0.02	31.00†		
Gap for check-sum character	0.11		
Time for Read or Write	33.08†	33.08†	
Free for computing, till next PE 2		10.59‡	

Time from PE 2 till Read or Write command must be given.....min 2.06

If the program is synchronized with the drum:
Read, compute, Write, compute, Read, etc., not using interrupt—
Computing time available between Read and Write commands.....min 11.68

†Read/Write time reduced for block less than 1550 slabs
‡Free time increased for block less than 1550 slabs

UNBUFFERED PRINTER

650 lines per minute, alphanumeric
805 lines per minute, numeric
1850 lines per minute, buffered list
Cylinder revolution rate 805 RPM
Paper movement 5400 lines per minute

Alpha, slew before:

SELP command	0.10
PRNT command setup, synchronize, etc.	1.97
Slew 1 line	17.50†
One revolution	74.53
	94.10†

†Plus 11.11 ms per blank line

Alpha, slew after:

SELP command	0.08
PRNT command setup, synchronize, etc.	0.75
One revolution	74.53
Slew 1 line	shareable 17.50†
	92.76†

†Plus 11.11 ms per blank line

Numeric, slew after:

PROCESSOR		PRINTER		
SELP command	0.10			
PRNT command setup	0.08			
Synchronize	0.67	Synchronize	0.67	one revolution 74.53
16 sectors	21.30	16 sectors	21.30	
Shareable time	52.38	Slew 1 line	17.50	
Next SELP and PRNT	0.18	Balance of revolution	35.06†	
Synchronize	0.67	Synchronize	0.67	

†Enough time for 2 blank lines if desired

List, slew after:

Processor time per line:

SELP command	0.10
PRNT command	1.34
	1.44

Printer time per line:

Print	14.91
Slew 1 line	17.50†
	32.41†

†Plus 11.11 ms per blank line

An Educational Publication
Marketing Services Department
THE NATIONAL CASH REGISTER COMPANY — DAYTON 9, OHIO

PRINTED IN U.S.A. SP-1128 E5TTT